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Animal Performance, Carcass Quality, and Tissue Residues with Beef Steers Fed Forage Sorghum Silages Grown on Soil Treated with Liquid Digested Sludge

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CROPS SECTION

Animal Performance, Carcass Quality, and Tissue Residues with Beef Steers Fed Forage Sorghum Silages Grown on Soil Treated with Liquid Digested Sludge[1]

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ABSTRACT

Processed sewage sludges are a renewable resource which have potential as a fertilizer material on agricultural land. Forage sorghum [*Sorghum bicolor* (L.) Moench] silages, grown on soil treated with Pensacola liquid digested sludge (LDS) turned under prior to planting, were fed as the main ingredient in the diet of beef steers to determine the effects on animal performance, carcass quality, and concentrations of selected potentially toxic metals in liver, muscle, and kidney tissues. The experimental diets consisted of (1) Control (normal fertilization), (2) LDS #1, 15 cm/ha of LDS, and (3) LDS #2, 22.5 cm/ha of LDS. Inclusion of silages grown on soil treated with LDS in the diets had no effect on animal performance and carcass quality measurements of beef steers. The cadmium (Cd) concentrations were lower ($P<0.05$) in the livers of steers fed the LDS #1 diet. The reason for this was not apparent. However, the concentrations of copper (Cu) in livers of steers fed the LDS diets were lower ($P<0.01$) than those of steers fed the Control diet, while the concentrations of iron (Fe) in livers of steers fed the LDS #2 diet were lower ($P<0.01$) than those of steers fed the Control and LDS #1 diets. This indicates that the metals in LDS, when the sludge was used as a fertilizer for growing forage sorghum fed to steers as silage, were accumulated to some extent in the plants and had an effect at the absorption site and/or at the liver storage site by decreasing the Cu and Fe concentrations. Since beef liver is considered to be a good source of Cu and Fe in the human diet, low liver concentrations of these two metals would not be desirable. From the standpoint of the beef animal, low Cu and Fe nutrition could cause anemia. There was no statistically significant difference among treatments in the concentrations of selected metals in muscle and kidney tissues.

Additional Index Words: Selected Metals, Liver, Muscle, Kidney, Blood, Feces.

INTRODUCTION

Forage sorghum [*Sorghum bicolor* (L.) Moench] silage, properly supplemented, is a feed with good potential for growing calves or finishing steers in northwest Florida (2, 3). Sorghum, especially the forage varieties from which two harvests (a first crop and a ratoon crop) per growing season can normally be obtained, can produce substantially more forage per unit of land than corn (*Zea mays* L.) (7).

Sludges have potential as a fertilizer on cropland (8, 10). Livestock performance was not affected when crops grown on land receiving applications of digested sewage sludge were fed (9, 13). However, metal contaminants contained in sludges can accumulate in plant tissues (6). This could be of concern from a human health standpoint when human and industrial wastes are applied to land intended for the production of forage for consumption by food animals (5).

The purpose of this study was to evaluate the effects of forage sorghum silages, grown on soil treated with various levels of Pensacola liquid digested sludge (LDS) prior to planting, in diets of beef steers on performance, carcass quality, and concentrations of selected potentially toxic metals in liver, muscle, and kidney tissues.

MATERIALS AND METHODS

Twenty-four steers approximately 9 to 12 months of age with an average wieght of 178 kg were weighed and allotted at random from European breed groups to six experimental groups of four steers each. The six experimental groups, utilizing two groups (replicates) per treatment, were assigned to the three following treatments:

1. Control—diet containing forage sorghum silage grown on soil fertilized with 36 kg/ha of nitrogen (N), 48 kg/ha of phosphorus (P), and 90 kg/ha of potassium (K) at planting time and sidedressed with 75 kg/ha of N at the first cultivation.
2. LDS #1—diet containing forage sorghum silage grown on soil treated with surface applications totaling 15 cm/ha (39 metric tons/ha of dry material) of Pensacola LDS turned under prior to planting.
3. LDS #2—diet containing forage sorghum silage grown on soil treated with surface applications totaling 22.5 cm/ha (59 metric tons/ha of dry material) of Pensacola LDS turned under prior to planting.

From a utilization standpoint, the two sludge rates were two and three times, respectively, the rate which would be normally recommended. The high sludge rates were used to deliberately try to create a situation where the metals could accumulate in sufficient quantities in the sorghum plants to create a potential problem for animals consuming the plants.

The feedlot diets consisted of 95% forage sorghum

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silage (31% dry matter) and 5% concentrate supplement mixture (89% dry matter) on an as-fed basis. These diets were 87% forage sorghum silage and 13% concentrate supplement mixture on a dry matter basis. The ingredients of the concentrate supplement mixture are listed in Table 1.

After an overnight shrink, individual animal weights were obtained at the beginning and end of the experiment. Group weights were obtained every 28 days during the interim period. These weights were obtained in order to periodically check on the performance of the steers on each of the three diets. Blood, fecal, and feed ingredient samples were collected each time the steers were weighed.

The trial was initiated on 22 February and terminated on 9 August, 1978 (168 days). The steers were fed *ad libitum* once daily. The amounts of feed for each diet were recorded at each feeding.

At the end of the feeding period, the steers were slaughtered at the University of Florida Meats Laboratory, Gainesville. Liver, muscle, and kidney tissues were collected at slaughter. Carcass measurements were obtained by trained personnel at the Meats Laboratory.

The LDS, feed ingredient, blood, fecal, and tissue samples were sent to the Analytical Research Laboratory, Soil Science Department, University of Florida, Gainesville for metal analyses. Samples were measured by volume (blood) or weight, dried where appropriate (feed ingredients, LDS, and feces), wet-ashed, dissolved in 0.2% nitric acid, and determinations were made with an emission or absorption flame spectrophotometer. Concentrations of selected metals in the sludge and feed ingredients are listed in Table 2.

Analyses of variance for animal performance and carcass quality data were conducted according to the method of Snedecor (11). The metal concentration data for blood, feces, and tissues (liver, muscle, and kidney) between treatments were tested for significance of variances by the SAS computer method (Statistical Analysis System—North Carolina State University) (1).

TABLE 1.—COMPOSITION OF THE CONCENTRATE SUPPLEMENT MIXTURE.

Ingredients	%
Soybean meal (44% protein)	82.3
Urea—45% N	6.4
Dicalcium/monocalcium phosphate	7.5
Salt (trace-mineralized)†	3.8
Vitamin A supplement‡	+

†Contained not less than 0.350% Zn, 0.340% Fe, 0.200% Mn, 0.033% Cu, 0.007% I, and 0.005% Co.

‡Added at the level of 22.05 million IU/metric ton or 22,050 IU/kg of concentrate supplement mixture.

RESULTS AND DISCUSSION

Performance and carcass data of steers receiving the three forage sorghum silage diets for the 168-day period are shown in Table 3. Steers fed the Control diet had an average daily gain of 0.55 kg per head, followed by 0.54 kg/head for steers fed the LDS #2 diet and 0.45 kg/head for steers fed the LDS #1 diet. There was no statistically significant difference among treatments in average daily gain. This was probably due to the limited number of observations and the large variation in individual gain within treatment groups. Steers receiving the Control diet were 22.4 and 2.4% more efficient in converting feed to gain than those receiving the LDS #1 and LDS #2 diets, respectively. Feed consumption was not affected by the LDS treatments. The average carcass yield grade was lower ($P<0.05$) for steers receiving the Control diet than that of steers receiving the LDS diets. This was probably due to chance and did not represent true treatment differences. There was no statistically significant difference among treatments as far as any of the other carcass parameters were concerned.

Concentrations of selected metals in blood and feces are listed in Table 4. The copper (Cu) concentrations in blood of steers fed the LDS diets were lower ($P<0.01$) than those of steers fed the Control diet, while the iron (Fe) concentrations in blood of steers fed the LDS #2 diet were lower ($P<0.01$) than those of steers fed the Control diet. Earlier studies with dried LDS fed in the diets of feedlot steers also showed slightly lower concentrations of Cu in the blood of steers receiving LDS (4). Underwood (12) stated that interactions exist between metals, such as Fe, zinc (Zn), cadmium (Cd), Cu, and others, which interfere with absorption. Apparently, these metals compete for protein-binding sites in the intestinal mucosa. This may account for the lower concentrations of Cu and Fe in blood of steers consuming forage sorghum silages grown on soil treated with LDS. The Cd, Cu, and Zn concentrations in feces of steers fed the LDS diets were higher ($P<0.05$ for Cu; $P<0.01$ for Cd and Zn) than those of steers fed the

TABLE 2.—CONCENTRATIONS OF SELECTED METALS IN PENSACOLA LIQUID DIGESTED SLUDGE AND FEED INGREDIENTS IN THE EXPERIMENTAL DIETS.

Metals	Pensacola sludge†	Control silage‡	LDS #1 silage‡	LDS #2 silage‡	Concentrate supplement mixture‡
			(mg/kg dry wt)		
Cd	12	≤0.17	0.25	0.31	0.38
Co	68	≤0.99	1.56	<0.10	2.19
Cr	282	2.19	≤2.21	≤0.68	2.81
Cu	587	9.94	7.88	5.82	14.25
Fe	5,416	782	1188	1019	641
Ni	51	2.19	≤0.39	≤0.39	3.75
Pb	526	≤0.39	<0.10	≤0.39	≤0.39
Zn	3,393	63.13	47.81	79.06	113.13

†Solids average 2.6%.

‡Each feed ingredient mean was based on four observations.

TABLE 3.—PERFORMANCE AND CARCASS DATA OF BEEF STEERS RECEIVING DIETS CONTAINING FORAGE SORGHUM SILAGES GROWN ON SOIL TREATED WITH VARIOUS RATES OF PENSACOLA LIQUID DIGESTED SLUDGE PRIOR TO PLANTING.†

Item	Treatments		
	Control diet	LDS #1 diet	LDS #2 diet
No. of animals	8‡	8	8
Length of trial, days	168	168	168
Avg initial wt, kg	176	179	179
Avg final wt, kg	269	254	269
Avg gain/animal, kg	93	75	90
Avg daily gain, kg	0.55 ± 0.18	0.45 ± 0.08	0.54 ± 0.06
Feed/gain ratio	28.6	35.0	29.3
Feed/animal/day, kg	15.7	15.6	15.8
Avg carcass quality grade§	11.1 ± 1.0	11.4 ± 1.7	11.3 ± 0.9
Avg carcass yield grade	1.6a* ± 0.2	1.9b ± 0.1	1.8b ± 0.2
Avg hot carcass wt, kg	143	135	145
Avg dressing percent	53.2 ± 1.8	53.1 ± 1.6	53.9 ± 4.7

†Data presented as means ± SD where appropriate for eight observations.
‡Two groups of four steers each.
§10 = low Standard, 11 = average Standard, 12 = high Standard, etc.
*Means in a row followed by different lower case letters differ significantly (P<0.05).

Control diet. These results are not in complete agreement with the concentrations of the metals in the feed ingredients (Table 2).

Concentrations of selected metals in liver, muscle, and kidney tissues are shown in Table 5. The Cd concentrations were lower (P<0.05) in livers of steers receiving the LDS #1 diet. The reason for this was not apparent. However, the concentrations of Cu in livers of steers fed the LDS diets were lower (P<0.01) than those of steers fed the Control diet, while the concentrations of Fe in livers of steers fed the LDS #2 diet were lower (P<0.01) than those of steers fed the Control and LDS #1 diets. This agreed with previous studies with steers fed diets containing Pensacola LDS (4). Again this indicates that the metals in Pensacola LDS, when the sludge was used as a fertilizer for growing forage sorghum fed to steers as silage, were accumulated to some extent in the sorghum plants and had an effect at the absorption site and/or at the liver storage site by decreasing the Cu and Fe concentrations. Since beef liver is considered to be a good source of Cu and Fe in the human diet, low liver concentrations of these two metals would not be desirable. From the standpoint of the beef animal, low Cu and Fe nutrition could lead to anemia over a period of time (12). There was no statistically significant difference among treatments in the concentrations of the selected metals in muscle and kidney tissues (Table 5).

TABLE 4.—CONCENTRATIONS OF SELECTED METALS IN BLOOD AND FECES.†

Metals	Treatments		
	Control diet	LDS #1 diet	LDS #2 diet
No. of observations	40	40	40
	(Blood, mg/liter)		
Cd	<0.01	<0.01	<0.01
Co	<0.16 ± 0.08	<0.16 ± 0.08	<0.17 ± 0.09
Cr	<0.10	<0.10	<0.10
Cu	0.82B** ± 0.14	0.52A ± 0.22	0.59A ± 0.23
Fe	482B ± 65	458A,B ± 76	419A ± 62
Ni	<0.10	<0.10	<0.10
Pb	<0.10	<0.10	<0.10
Zn	4.18 ± 0.51	3.91 ± 0.61	3.96 ± 0.92
No. of observations	34	33	31
	(Feces, mg/kg dry wt)		
Cd	0.29A ± 0.19	0.56B ± 0.28	0.54B ± 0.19
Co	1.00 ± 1.06	1.32 ± 0.80	1.78 ± 1.59
Cr	4.58 ± 2.97	4.02 ± 1.55	3.77 ± 1.73
Cu	14.57a* ± 7.52	16.28b ± 4.63	17.11b ± 5.12
Fe	2947 ± 860	2994 ± 823	2705 ± 957
Ni	4.61 ± 1.35	4.00 ± 1.32	4.31 ± 1.22
Pb	2.27 ± 1.35	1.88 ± 1.44	1.84 ± 1.96
Zn	96.9A ± 33.0	205.4B ± 54.0	224.5B ± 90.5

†Data presented as means ± SD where appropriate.
*Means in a row followed by different lower case letters differ significantly (P<0.05).
**Means in a row followed by different capital letters differ significantly (P<0.01).

TABLE 5.—CONCENTRATIONS OF SELECTED METALS IN LIVER, MUSCLE, AND KIDNEY TISSUES.†

Metals‡	Treatments		
	Control diet	LDS #1 diet	LDS #2 diet
No. of observations	8	8	8
	(Liver, mg/kg wet wt)		
Cd	0.12^{b*} ± 0.01	0.08^{a} ± 0.01	0.11^{b} ± 0.03
Cu	8.61^{B**} ± 6.27	2.11^{A} ± 0.42	3.14^{A} ± 1.61
Fe	368^{B} ± 111	350^{B} ± 120	185^{A} ± 73
Zn	33.1 ± 4.1	31.6 ± 3.8	30.6 ± 3.7
	(Muscle, mg/kg wet wt)		
Cd	<0.01	<0.01	<0.01
Cu	0.48 ± 0.06	0.50 ± 0.12	0.50 ± 0.09
Fe	22.5 ± 14.8	16.4 ± 2.8	16.8 ± 4.7
Zn	45.1 ± 5.0	44.8 ± 6.1	38.2 ± 8.4
	(Kidney, mg/kg wet wt)		
Cd	0.46 ± 0.18	0.30 ± 0.11	0.40 ± 0.24
Cu	3.23 ± 0.32	2.90 ± 0.35	3.20 ± 0.60
Fe	113.9 ± 11.0	96.9 ± 31.5	89.3 ± 17.7
Zn	17.9 ± 1.6	18.0 ± 1.8	17.6 ± 1.3

†Data presented as means ± SD where appropriate for eight observations.

‡Co, Cr, Ni, and Pb concentrations in the three tissues for all treatments were below the detection limit of the spectrophotometer and were omitted in the table.

*Means in a row followed by different lower case letters differ significantly ($P<0.05$).

**Means in a row followed by different capital letters differ significantly ($P<0.01$).

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